EAST Browser - L5: [51] ophthalmic n... | US 5581347 A | Tag: S | Doc: 20/51 | Format : KWIC

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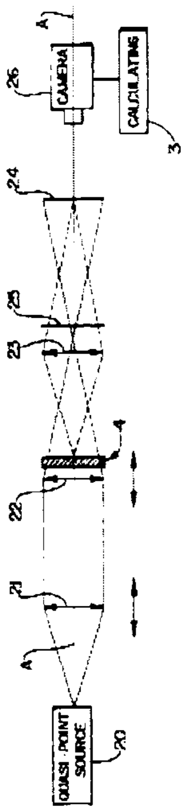

FIG. 3

US-PAT-NO: 5581347

DOCUMENT-IDENTIFIER: US 5581347 A

TITLE: Optimization method and device for (
component

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Brief Summary Text - BSTX:

Finally, in the device described in French p
map of the slopes of the actual surface to b
deflectometry using phase detection and, aft
nominal theoretical surface from the map of
obtained, it is simple to obtain a map of th
enabling the actual surface to be reconstruc
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implements a relative method involving prior
of the surface to be measured.

	Document ID	Kind Codes	Sou
14	US 5805276 A		USPAT
15	US 5801822 A		USPAT
16	US 5748300 A		USPAT
17	US 5745230 A		USPAT
18	US 5717781 A		USPAT
19	US 5604583 A		USPAT
20	US 5581347 A		USPAT
21	US 5528357 A		USPAT

L Number	Hits	Search Text	DB	Time stamp
1	176	356/124 and inspect$3 near3 lens	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	[illegible]
2	[illegible]	inspect$3 near6 (ophthalmic near lens)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/04/04 11:16
4	4	(inspect$3 near6 (ophthalmic near lens)) and aperture and diffuse and holder	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/04/04 11:17
3	3	(inspect$3 near6 (ophthalmic near lens)) and aperture and diffuse and lens near holder	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2003/04/04 11:17

US-PAT-NO: 5500732

DOCUMENT-IDENTIFIER: US 5500732 A

TITLE: Lens inspection system and method

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FIG. 3 is a plan view of an **ophthalmic lens that may be inspected** in the system of FIG. 1.

Lenses 42 and 44 are positioned so that they form a lens assembly that focuses different portions of light beam 92 at different locations. In particular, this lens assembly focuses a portion of the light beam 92 that passes through the ophthalmic lens 74 being tested, onto an image plane, specifically pixel array 52. This lens assembly also focuses a portion of light beam 92 onto a focal point, schematically referenced at 42a in FIG. 2, in front of the image plane to form a **diffuse** background pattern on the image plane.

Since the lens package 82 has a curve to form a gravitational potential to center the lens in cavity 86, the package acts as a lens within the imaging subsystem 16. For example, with an embodiment of the invention that has actually been reduced to practice, package 82 acts as a lens with a focal lens of 25 mm. Thus, the light exiting package 82, if uncorrected, would sufficiently diverge prior to entering the camera lens 56 so as to miss the camera **aperture**. This would tend to underilluminate the image of the lens under test, and reduce the available contrast in the image

of the lens produced
on pixel array 52. To correct for this divergence, field lens 44 is placed
under the package 82 to counteract the optical power of the solution in the
package cavity 86.

The camera lens **aperture** was set at f/4 with a field of view of 14.495 mm
(lenses 74 in deionized water may be about 12.2 mm in diameter). Attached to
the end of the camera lens was an Andover bandpass filter centered at a
wavelength of 550 nm, with a 10 nm full wave half height window. Such a filter
removes all possibility of chromatic aberrations, improves overall spatial
resolution, and maintains a photopic response to the lens inspection similar to
an inspector's ocular response. It also removes infrared light at the CCD
detector. This is advantageous since such light would decrease the overall
system modulation transfer function.

iv) a lens assembly to focus a portion of the light beam passing through the
lenses onto an image plane, and to focus a portion of the light beam onto a
focal point in front of the image plane to form a **diffuse** background pattern on
the image plane.

focusing a portion of the light beam onto a focal point in front of the
image plane to form a **diffuse** background pattern on the image plane;

a **lens holder** for holding the lenses in an inspection position;

ii) a diffuser located in a path of the light beam to **diffuse** the light
beam, and

iii) a lens assembly located in the path of the light beam to focus a

portion of the light beam passing through the lenses onto
the pixel array, and
to focus a portion of the light beam onto a focal point in
front of the pixel
array to form a **diffuse** background pattern on the pixel
array;

locating a diffuser in a path of the light beam to
diffuse the light beam;

US-PAT-NO: 5818573

DOCUMENT-IDENTIFIER: US 5818573 A

TITLE: Opthalmic lens inspection system

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An **ophthalmic lens inspection** system includes an illumination assembly which generates **diffuse** light and transmits the **diffuse** light through an **ophthalmic lens disposed in an inspection** position, the **diffuse** light having a diffusivity of between 30.degree. and 50.degree.. An imaging assembly generates a set of signals representing selected portions of the **diffuse** light transmitted through the **ophthalmic lens in the inspection** position. A moving mechanism supports the imaging and illumination assemblies for common movement relative to the contact lens, to bring a reference point into alignment with the center of the imaging assembly.

Some automated systems have been developed for automatically inspecting contact lenses. One such system is disclosed in U.S. Pat. No. 5,500,732 issued to Ebel et al on Mar. 19, 1996. In this system, a multitude of ophthalmic lenses are continuously moved along a path through a lens inspection station by a walking beam mechanism. At the lens inspection station, the lenses are moved at a constant velocity under cameras, each camera inspecting a different lens, and the lenses are imaged. In the inspection station, the lenses are illuminated by strobe light through a ground glass diffuser, an air spaced doublet collector lens, and a field lens. The

doublet lens is to
collimate the light from the ground glass diffuser and focus a portion of the
light beam onto a focal point forward of a imaging pixel array, and the field
lens is to focus a portion of the **diffuse** light onto the pixel array and for
correcting divergence of the light beam caused by the lens package (holder,
water and lens) under inspection, according to the Ebel et al. patent. This
illumination subsystem purportedly provides a **diffuse** background pattern on the
image plane giving the peripheral zones of the lenses a different grey level
than the back optic zone to enhance the image of the boundary between the
peripheral bevelled zone and the central optical zone of the contact lenses.
The images of each of the lenses are then processed to locate the lens in the
image and to detect various defects such as torn lenses and cosmetic flaws
known as puddles formed by slight depressions in the surface of the lens.

There are a number of problems with this type of illumination system. One
problem is that this type of illumination system requires precise alignment and
spacing of the optical elements if the desired quality of the image and the
desired results are to be obtained. For instance, if the doublet lens is
slightly out of position along the optical axis of the camera and focusses the
diffuse light on the pixel array, an image of the ground glass will be
superimposed on the image of the lens, thus diminishing the quality of the
image and the inspection results. Also, this system captures an image of the
lenses and depends on computer processing to reject features of the lens that
are not of interest. Also, the Ebel et al system requires an extra field lens
to undo the optical properties of the lens package being

inspected.

Another example of an automatic **ophthalmic lens inspection** system is disclosed in European Patent Application 0 604 178 A1, which describes a strobe illumination system. The strobe illumination reportedly permits a lens to be electronically imaged while the lens is in motion and suppresses the details of the light source and the lens package by providing a **diffuse** strobe illumination. The strobe illumination is provided by a 5 joule strobe lamp, a flashed opal diffuser and an operative adjacent the ophthalmic lens. Selective spacing and **aperture** diameter control the cone angles of the **diffuse** light passing through the ophthalmic lens to suppress details of the lens package and lamp.

Another example of automatic **ophthalmic lens inspection** system is disclosed in European Patent Application 0 604 692 A2, which uses dark field illumination using a pair of imaging lenses where only deflected light is imaged.

Further, it would be advantageous to avoid using a strobe light to image an **ophthalmic lens continuously moving past on an inspection** point as disclosed in U.S. Pat. No. 5,500,732, and European Patent Applications 0 604 178 A1 and 0 604 180 A2.

The present invention relates to an apparatus for positioning an **ophthalmic lens with respect to an inspection** instrument such as one or more cameras for inspecting the lens. The apparatus comprises a transparent surface on which a contact lens can be placed, an illuminator for illuminating a contact lens disposed on the surface, an imaging device directed toward a side of the lens

in a direction substantially perpendicular to the surface for capturing an image of at least a portion of an outer edge of the contact lens, an analyzer for receiving the image and determining therefrom a geometrical center of the lens and a relationship between the center and a reference point which is fixed with respect to the imaging device and the inspection instrument, and moving means for moving the imaging device and the inspection instrument together relative to the contact lens to bring the reference point into alignment with the center.

Further, the present invention avoids using the complicated optics disclosed in U.S. Pat. No. 5,500,732, and avoids the need for **aperture** and spacing adjustments disclosed in European Patent Application 0 604 178 A1. Instead, the present invention uses bright field imaging provided by means of an extended **diffuse** light source which fills the image cone of the camera, in conjunction with a small **aperture** to provide a large depth of field to reduce or eliminate the effects of the optical properties of the lens and **lens holder** (if any) being inspected. The **diffuse** light source preferably has a diffusivity within the limited range of between 20.degree. and 60.degree., and even more preferably between 30.degree. and 50.degree., and most preferably has a diffusivity of 35.degree..

Also, another advantage of the present invention is that, unlike the system disclosed in U.S. Pat. No. 5,500,732, it does not have to compensate for the focussing power of the **ophthalmic lens being inspected, the lens holder,** or water in which the lens might be emersed. It is largely independent of the focussing power of these components and it will work on

non-hydrated or hydrated lenses (whether emersed in water or not).

An additional advantage of the inventive system is that the side camera(s) focus on only a portion of the **ophthalmic lens being inspected,** which results in higher resolution images of the lens.

FIG. 6 is a side elevational view of a focusing mechanism, achromatic lens and **aperture** of cameras of the imaging assembly depicted in FIG. 1;

A requirement of an illumination system used to inspect transparent objects is to provide a source of light which is sufficiently **diffuse** as to obscure details of the light source or other elements of the illumination system.

In the present system for inspecting ophthalmic lenses, the illumination system is designed to generate **diffuse** light to pass through the ophthalmic lenses C in the inspection zone Z. In order to avoid the need for aligning field lenses or collimating lenses which have been used in earlier systems to provide some degree of directivity, the diffusivity of each of the illumination devices 86, 86' of the illumination assembly 16 is preferably selected to be between 20.degree. and 60.degree., and more preferably between 30.degree. and 50.degree.. The most preferred diffusivity is about 35.degree.. Diffusivity is specified as a full width angle at which a 10% maximum of the light intensity is found off the normal axis of the intensity curve.

As shown in FIGS. 1 and 2, there is one illumination device 86 for each of the side cameras 100 and an additional illumination device 86' for the central camera 100'. These illumination devices 86, 86' are

diametrically opposed to the respective cameras 100, 100' with reference to the contact lens C and provide an extended **diffuse** light which fills the image cone of the camera, in conjunction with the small **aperture** in front of the camera.

As can be seen, the illumination devices 86, 86' require no lenses to provide directivity to the **diffuse** light. If the light were totally **diffuse,** (e.g., 90.degree. diffusivity) without the intervention of optics, it would be difficult to image any details of the **ophthalmic lens C in the inspection** position. Too little diffusivity would tend to allow an image of the light source to impinge on the cameras 100, 100', thus deteriorating the image of the ophthalmic lens C.

Another alternative is to provide an electro-luminescent panel 178 as a **diffuse** area source. Such an electro-luminescent panel 178 is shown in FIG. 8 as the central illumination device 86'. The intensity of such an electroluminescent panel is lower and includes life duration problems due to aging. Additionally, it tends to be too **diffuse,** when compared to the LED arrays 161. Thus, it results in a low contrast.

The imaging system includes a central camera 100' to image the entire contact lens C in the inspection station and at least one radially positioned side camera 100 to image a side portion of the contact lens C. In a preferred embodiment, there are eight side cameras 100, the optical axes of which are radially disposed at 45.degree. with reference to one another and 45.degree. to the plane of the **ophthalmic lens in the inspection** position. The cameras can be any suitable type, such as the Toshiba CCD camera IK-541RA.

As shown in FIG. 4, each of the side cameras 100 is mounted to the horizontal imaging table 82 at a 45.degree. angle thereto. As shown in FIG. 5, the central camera 100' is perpendicularly mounted to the horizontal imaging table 82 at a central portion thereof. FIG. 6 shows the details of the front end of the cameras 100, 100', including a focusing mechanism 116, achromatic lens 114, and **aperture** 118 of the cameras 100, 100'. The achromatic lens 114 is mounted in a **lens holder** 108 by a snap ring and shims. Shims are required to load the achromatic lens 114 by means of O-rings within the **lens holder** 108 as shown in FIG. 6. This **lens holder** 108 is mounted in an axially adjustable carriage 119 which also possesses the **aperture** 118. A portion 119' of the carriage 119 is threadingly mounted to a front housing 117 of the cameras 100, 100'.

The **aperture** 118 is not diffraction limited and is preferably 2 to 3 millimeters in diameter. The **aperture** 118, however, is small to provide a greater depth of focus and to limit the range of the collimated light to prevent light deviated from defects in the contact lens C from reaching the imaging plane of the cameras 100, 100'. An optional color filter can be added to this part of the system.

The combination of the small **aperture** 118, which provides a large depth of field, and the extended **diffuse** light from the illumination devices 86, 86' which fill the image cone of the cameras 100, 100', provides bright field imaging wherein light that is sharply bent due to defects in the lens being imaged to be outside the acceptance cone of the camera will not be imaged on

the cameras 100, 100' and therefore appears as dark spots, but only the light that is softly bent (and therefore inside the acceptance cone) is imaged. If there are no defects or dirt on the lens, the camera would see nothing (other than the edge of the lens as a contrasting line in the otherwise bright field, as shown in FIG. 7). Also, the use of the side cameras 100 to image only a portion of the contact lens C increases the overall resolution used in the lens inspection.